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EXECUTIVE SUMMARY

THE DROUGHT OF 1990

IN

THE WESTERN STATES AND OUTLOOK FOR 1991

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

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U.S. DEPARTMENT OF THE INTERIOR

MARCH 3, 1849

Mission: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.

CANADA
MEXICO
GULF OF MEXICO
EXPLANATION
REGION HEADQUARTERS
REGIONAL BOUNDARY
PSMB - PICK-SLOAN MISSOURI BASIN PROGRAM
CRSP - COLORADO RIVER STORAGE PROJECT
CVP - CENTRAL VALLEY PROJECT
CRBSCP - COLORADO RIVER BASIN SALINITY CONTROL PROJECT
CUP - CENTRAL UTAH PROJECT
BCP - BOULDER CANYON PROJECT
SLVP - SAN LUIS VALLEY PROJECT
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WESTERN UNITED STATES
SHOWING LOCATION OF
BUREAU OF RECLAMATION PROJECTS
(PROJECTS COMPLETED AND UNDER CONSTRUCTION)
MAP No X-D-4151
SCALE OF MILES
SCALE OF KILOMETERS
1988
FOR PHYSICAL DATA ON DAMS, SEE MAPS
"FEDERAL RECLAMATION STORAGE DAMS," X-D-4153S
"FEDERAL RECLAMATION DIVERSION DAMS," X-D-4153D
OKANOGAN
CHIEF JOSEPH DAM
RATHDRUM (PRAIRIE)
SPOKANE VALLEY
HUNGRY HORSE
AVONDALE
SUN RIVER
MILK RIVER
BUFORD TRENTON
COLUMBIA BASIN
DALTON GARDENS
MISSOULA VALLEY
FRENCHTOWN
FORT PECK
INTAKE
BUFFALO RAPIDS
YAKIMA
THE DALLES
TUALATIN
LEWISTON ORCHARDS
BITTER ROOT
WAPINITIA
UMATILLA
DESCHUTES
BAKER
CRESCENT LAKE
BURNT RIVER
CROOKED RIVER
VALE
ARNOLD
MARN CREEK
BOISE
LITTLE WOOD RIVER
HUNTLEY
SHOSHONE
LOWER YELLOWSTONE
GRANTS PASS
ROGUE RIVER BASIN
KLAMATH
OWYHEE
MINIDOKA
PALISADES
RAPID VALLEY
KENDRICK
MICHAUD FLATS
NEWTON
HYRUM
EDEN
SEEDSKADEE
MIRAGE FLATS
NORTH PLATTE
ORLAND
HUMBOLDT
OGDEN RIVER
WEBER BASIN
LYMAN
COLORADO-BIG THOMPSON
PROVO RIVER
WEBER RIVER
NEWLANDS
SOLANO
TROCKEE STORAGE
WASHOE
STRAWBERRY VALLEY
CENTRAL UTAH
MOON LAKE
COLLBRAN
GRAND VALLEY
FRUITGROWERS DAM
SCOFIELD
EMERY CO
BOSTWICK PARK
UNCOMPAHGRE
PAONIA
SMITH FORK
FRYINGPAN ARKANSAS
DALLAS CREEK
MANCOS
SAN LUIS VALLEY
PINE RIVER
IVERMEJO
FLORIDA
HAMMOND
SAN JUAN-CHAMA
CANADIAN RIVER
WICHITA
ROBERT B GRIFFITH WATER
BOULDER CANYON
SANTA MARIA
CACHUMA
VENTURA RIVER
PARKER DAVIS
PALO VERDE
COLO RIVER FRONT WORK AND LEVEE SYSTEM
CENTRAL ARIZONA
SAN DIEGO
YUMA
GILA
YUMA AUXILIARY
SALT RIVER
MIDDLE RIO GRANDE
TUCUMCARI
FORT SUMNER
WASHITA BASIN
NORMAN
W C AUSTIN
ARBUCKLE
MOUNTAIN PARK
McGEE CREEK
PECOS RIVER BASIN WATER SALVAGE
BRANTLEY
CARLSBAD
McMILLAN DELTA
RIO GRANDE
BALMORHEA
SAN ANGELO
COLORADO RIVER
AMISTAD
PALMETTO BEND
NUECES RIVER
FALCON
LOWER RIO GRANDE REHABILITATION
Desalting Complex - CRBSCP
Los Vegas Wash - CRBSCP
Grand Valley - CRBSCP
Paradox Valley - CRBSCP
Closed Basin - SLVP
Vernal - CUP
Uintah - CUP
Jensen - CUP
Bonneville - CUP
Upalco - CUP
Vallecito - CRSP
Pilot Butte - PSMB
Shadehill - PSMB
Angostura - PSMB
Rapid Valley - PSMB
Keyhole - PSMB
Glendo - PSMB
Kortes - PSMB
Boysen - PSMB
Riverton - PSMB
Owl Creek - PSMB
Hanover - Bluff - PSMB
Yellowtail - PSMB
Crow Creek Pump - PSMB
Fort Benton - PSMB
Helena Valley - PSMB
Canyon Ferry - PSMB
Lower Marias - PSMB
Garrison - PSMB
Dickinson - PSMB
Ft Clark - PSMB
Heart Butte - PSMB
Rapid Fourche - PSMB
O'Neill - PSMB
Ainsworth - PSMB
Gorgonz - PSMB
Farwell - PSMB
North Loup - PSMB
Frenchman Cambridge - PSMB
Bostwick - PSMB
Kirwin - PSMB
Almena - PSMB
Webster - PSMB
Cedar Bluff - PSMB
Glen Elder - PSMB
Armel - PSMB
Fort Clark - PSMB
Scoggins - PSMB
Tualatin - PSMB
Trinity - CVP
Shasta - CVP
Sacramento Canals - CVP
American River - CVP
Sly Park - CVP
Auburn - Folsom South - CVP
Delta - CVP
New Melones - CVP
San Felipe - CVP
San Luis - CVP
Friant - CVP
Santa Maria
Cachuma
Ventura River
All-American Canal System - BCP
Desalting Complex - CRBSCP
Los Vegas Wash - CRBSCP
Grand Valley - CRBSCP
Paradox Valley - CRBSCP
Closed Basin - SLVP
Vernal - CUP
Uintah - CUP
Jensen - CUP
Bonneville - CUP
Upalco - CUP
Vallecito - CRSP
Pilot Butte - PSMB
Shadehill - PSMB
Angostura - PSMB
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Glen Elder - PSMB
Fort Clark - PSMB
Scoggins - PSMB
Tualatin - PSMB
Trinity - CVP
Shasta - CVP
Sacramento Canals - CVP
American River - CVP
Sly Park - CVP
Auburn - Folsom South - CVP
Delta - CVP
New Melones - CVP
San Felipe - CVP
San Luis - CVP
Friant - CVP
Santa Maria
Cachuma
Ventura River
All-American Canal System - BCP
Desalting Complex - CRBSCP

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November 1990

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INTRODUCTION

The Bureau of Reclamation (Reclamation) is the West's primary water resources management agency. Reclamation operates more than 350 storage dams, delivering about 30 million acre-feet of water each year. It serves the needs of approximately 25 million people, provides irrigation water to an average 10 million acres of land each year, and generates an average 45 billion kilowatt-hours of hydroelectric energy, annually. In addition, Reclamation provides recreation, fish and wildlife, water quality, and other water-related benefits to the citizens of the West.

The amount of water available to meet these purposes varies from year to year. Water supply largely depends upon the pattern of winter snowfall; summer precipitation is negligible in most areas of the West. During winters with average or high snowfall (and with temperatures cold enough to accumulate a snowpack), spring runoff is sufficient to fill reservoirs for the season's demands. However, when winter weather is too dry or too warm to accumulate mountain snowpack, reservoirs may not fill.

In many Reclamation reservoirs, one winter of deficient snowpack may be insignificant. These reservoirs were designed to account for such variable weather conditions; thus, sufficient carryover storage from the previous year is available. Other reservoirs were sized to meet the demand for water even if three consecutive years of inadequate snowpack occur. However, some older Reclamation reservoirs were not designed to meet this requirement. And, for most reservoirs, carryover storage is no longer available when drought conditions extend beyond three years.

That condition—four years of consecutive drought—has now occurred in some areas of the West. Based on current water supply conditions, it is possible that we are entering the fifth year of water shortages in some of the West's most populous regions. The demand for water has steadily increased, placing greater stress on water supplies even under normal conditions.

Population growth and a national consensus about the importance of water for other values, such as instream uses, have increased demands. New burdens have been placed on some water supplies that were, until recently, adequate to fulfill all needs. The water supply requirements of southern California are a particular example, where potential water shortages are possible even in normal water years.

Water users in some areas of the West are jointly dependent on surface water and ground-water resources. In years of drought, users are more likely to depend on ground water. Such use places more demand on aquifers at a time when less recharge is occurring due to dry surface conditions. Although the relationship between ground water and surface water is important, this document only

addresses surface water in relationship to Reclamation projects; it does not attempt to assess ground water concerns.

This report summarizes the drought conditions that occurred in many areas of the Reclamation West during water year 1990—from October 1, 1989, through September 30, 1990. Where information is available, some generalized predictions about the outlook for water supply in 1991 are provided. (For some Reclamation projects, reservoir operating plans for 1991 will not be prepared until after this report is published; therefore, the information herein may not represent the actual operating plans.) Next winter's precipitation patterns cannot be predicted with any degree of certainty; therefore, any predictions in this document should be treated as "educated guesses," based upon current conditions and the conditions expected if the winter season has high, average, or low precipitation.

The reader is cautioned that this report summarizes water supply conditions at some selected Reclamation projects; not all projects are represented. Projects were selected for inclusion in this document based upon the availability of data and the severity of potential impacts from drought. Further, the conditions of water supply do not necessarily correlate to the water demand from each project. Some projects are able to provide an adequate water supply for all needs even when reservoir storage appears to be particularly low. Therefore, water conditions must be examined in context of demand from each project, and comparisons between projects are not always appropriate. As a general rule of thumb, each project should be compared to its own historical record to determine the severity of water supply shortages. More detailed information about specific projects is available from Reclamation's regional offices:

Pacific Northwest Regional Office
John W. Keys, III, Regional Director
Box 043 - 550 West Fort Street
Boise, Idaho 83724-0043

Mid-Pacific Regional Office
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Lower Colorado Regional Office
Edward M. Hallenbeck,
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Upper Colorado Regional Office
Roland Robison, Regional Director
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Roger K. Patterson, Regional Director
P.O. Box 36900
Billings, Montana 59107-36900

OVERVIEW
1990 WATER SUPPLY AND OUTLOOK FOR 1991

Water resources projects in the Bureau of Reclamation are separated into five regions: Pacific Northwest, Mid-Pacific, Lower Colorado, Upper Colorado, and Great Plains (see frontispiece map). The following discussion summarizes 1990 water supply conditions—including soil moisture, snowpack, accumulated reservoir inflow, and reservoir storage—by regions and, where appropriate, provides a preliminary projection of 1991's water supply under potential streamflow scenarios.

Pacific Northwest Region

The Pacific Northwest Region includes the States of Washington, Idaho, and Oregon and portions of Wyoming and Montana. The region encompasses the drainage basins of the Columbia River and coastal Oregon and Washington rivers.

Water Year 1990

Soil moisture conditions indicated normal to mild drought at the beginning of the 1990 water year for most of the region. Improvement was indicated for parts of the region in mid-winter, but, by the end of the water year, conditions had degraded to an extreme drought situation for about half of the region. Overall, soil moisture indicated much worse conditions for the region at the beginning of water year 1991 than at the beginning of the previous (1989) water year.

Snow accumulation in the region's river basins was below normal throughout the snowfall season. The areas most affected by low snowfall were the Oregon river basins where snow accumulation was less than 50 percent of normal for most areas. One exception was the South Fork Flathead River in northwestern Montana, where the snowpack was in the normal range on May 1, 1990.

Accumulated reservoir inflow ranged from well below normal to well above normal throughout the region by December 31, 1989, with the worst conditions in the Boise and Payette Rivers basins in western Idaho and the best conditions on the South Fork Flathead River in northwestern Montana. Generally, conditions neither improved nor deteriorated overall throughout the water year; however, some degradation in conditions occurred in the Boise and upper Snake Rivers basins in southwestern Idaho.

The region started the 1990 water year with a wide range of storage conditions—from well below normal in the Snake and Boise Rivers basins in Idaho, the Yakima River basin in Washington, and the Flathead River basin in Montana, to well above normal in the Malheur and Umatilla Rivers basins in

Oregon. Conditions fluctuated somewhat in some areas throughout the year; but, by year's end, overall conditions had generally degraded. By September 30, 1990, most basins in Oregon had storage conditions of less than 70 percent of normal and some less than 50 percent of normal. In southern Idaho, most storage was less than 50 percent of normal at the end of the year, with the exception of the Payette River where storage was above normal. Storage in Washington and northwestern Montana was near normal at year's end.

Notwithstanding localized water supply conditions in water year 1990, project water deliveries were near normal to normal. Notable exceptions were in the Boise River basin in Idaho and in the Malheur and Crooked Rivers basins in Oregon. Overall, irrigation demand in the Boise River basin averaged only 80 percent of normal, indicating that farmers were conserving water. End-of-year storage in the Boise River basin was only 58 percent of normal; but that level is very good, considering the poor streamflow and low reservoir storage at the beginning of the season. End-of-year storage in Prineville Reservoir in the Crooked River Project in Oregon was 62 percent of normal—the second lowest end-of-year storage in the project's 30-year history.

Projected Conditions for 1991

Reclamation will begin to forecast the 1991 season runoff early in January 1991, when the first snowpack observations are made. No water supply predictions are made during the fall unless a special need arises, and in such instances only reservoir refill probability estimates based on historical data are possible.

In general, end of season carryover storage is below normal and below last year's volume in many projects within the region. The Minidoka Project (Idaho-Wyoming) storage is 37 percent of normal, Boise Project (Idaho) storage is 57 percent of normal, and Owyhee Project (Idaho-Oregon) storage is 52 percent of normal. Vale Project (Oregon) storage was completely depleted in mid-August and now remains near empty, with less than 1 percent of normal storage. The Crooked River Project (Oregon) storage is 54 percent of normal, and storage in the Rogue River basin (Oregon) is 52 percent of normal. Above average runoff next year at the above projects would recover the storage reserves.

Yakima Project (Washington) storage is very near normal (96 percent), having had a normal 1990 season. Following a careful irrigation operation, the Payette River (Idaho) system storage is 120 percent of normal, despite well below average runoff in 1990.

MID-PACIFIC REGION

The Mid-Pacific Region includes most of California and portions of Nevada and Oregon. Projects include the Central Valley Project in California and other smaller projects on streams originating in the Sierra Nevada, lower Cascade, and southern California mountain ranges.

Water Year 1990

Water year 1990 began with indications of a possible end to the 3-year drought in California with the occurrence of strong storms in late September and October of 1989. The Central Valley Project had averted water shortages over most of the project in 1989 by virtue of an extraordinarily wet March. It appeared that there was a high probability for full water deliveries in 1990. Unfortunately, the outlook then began to worsen steadily.

The 6-month period November 1989 through April 1990 (the normal rainy season in California) produced only a few moderate rain storms interspersed with prolonged periods of dry weather. In February, Central Valley Project water contractors and water rights holders served by the project were informed of impending deficiencies in their water supplies during 1990. Most contractors were cut to 50 percent supplies and water rights entities were cut to 75 percent of full supply. By May 1, 1990, conservative forecasts showed Central Valley Project storage dropping to 2.9 million acre-feet in order to support even the deficient water deliveries earlier committed to by Reclamation.

Then came the "miracle May" of 1990. Two series of storms, the second (and larger) over Memorial Day weekend, produced by far the greatest reservoir inflows of the entire water year. These storms resulted in the wettest May of record at many locations in California, including Shasta and Trinity Dams.

Inflow from the May storms dramatically modified the water supply forecasts at a time of year when they are usually already accurately established. Reclamation restored all water rights entities to 100 percent supplies, as required by their agreements. The Central Valley Project also made an additional 83,000 acre-feet of water available to wildlife refuges. However, with only about 50 percent of desirable carryover storage, the project is again at risk of deficiencies in 1991.

The four water years 1987, 1988, 1989, and 1990 constitute one of California's most severe droughts of this century. Under California's Sacramento River Index, water year 1989 was classified a "below normal" year; the other three water years 1987, 1988, and 1990 were "critical" years .

Natural runoff during the 4-year period 1987-1990 is the lowest for this century in the California River basins above New Melones, Friant, and Folsom Dams. Central Valley Project-wide, only the droughts of 1928-34 and 1976-77 are even

comparable in severity. Continuation of the present drought through 1991 could well constitute a "critical period" for the operation of the Central Valley Project more severe than those used to determine the yield and other capabilities of the project.

According to the indices of drought, measurements of soil moisture indicated very moist to mild drought to extreme drought conditions at the beginning of the 1990 water year. Conditions degraded as the water year progressed, and, by the end of the water year, conditions had degraded to an extreme drought situation for two-thirds of the region and moderate to severe drought for the remainder. Overall, soil moisture was much drier at the beginning of water year 1991 (September 30, 1990) than at the beginning of the previous water year (September 30, 1989.)

Snowpack in the tributary basins to the Central Valley in California was well below normal on February 1, 1990. By May 1, conditions had degraded to below 50 percent of normal in all basins. Consequently, accumulated inflow to the region's reservoirs was below normal to well below normal throughout the year. Some improvement and degradation were alternatively felt in various areas, but the year ended under similar circumstances to those at the beginning. Many areas had less than 50 percent of inflow for the year.

At the beginning of the 1990 water year, reservoir storage ranged from well below normal to near normal in the Central Valley of California and in the Klamath River basin in Oregon and California. Basins in southern California and in Nevada were, for the most part, well below normal at that time. Conditions degraded over the region through the water year and generally were well below normal throughout, except in the San Joaquin River basin where storage was near normal by year's end on September 30, 1990.

In Nevada, the Lahontan Project experienced water shortage conditions during 1990. In March, the Truckee-Carson Irrigation District set the Newlands Project water allocation at 65 percent of entitlement, but later revised the allocation to 70 percent due to rainfall during April. The Pershing County Water Conservation District initially set the Humboldt Project water allocations at 25 percent of entitlement but later adjusted the allocation to 27.5 percent, due to April precipitation. The water surface level of Lake Tahoe fell below its natural rim outlet to the Truckee River on September 14, resulting in conservation measures along the Truckee River. This is only the eleventh time since 1990 that the lake level has dropped so low.

Projected Conditions for 1991

Early analyses of water supply possibilities for 1991 indicate that full deliveries for Central Valley Project contractors will probably require normal or greater than normal runoff in 1991. The distribution of runoff throughout the project will have a bearing on water delivery capabilities because of the varying refill potential and

localized operational requirements at each reservoir. In general, if 1991 normal runoff is evenly distributed over the project reservoirs, full water deliveries can be supported and some refill of carryover storage can be provided. For this reason, only normal or drier water supply scenarios currently are being analyzed in detail.

Preliminary operations forecasts have been performed for water year 1991 using three water supply scenarios: "median," "dry," and "critical." These projections demonstrate that there is a significant risk of continuing severe drought conditions and water supply deficiencies in 1991. Depending on the severity of conditions, which at this time can only be cast in terms of historical water supply probabilities, operation of the Central Valley Project in water year 1991 could stretch project capabilities to their limits. The September 30, 1990, storage in Central Valley Project reservoirs was 3.98 million acre-feet. The projected September 30, 1991 storage for each of the three water supply scenarios is 5.6 (median), 4.0 (dry), and 3.2 (critical) million acre-feet.

The Newlands Project and certain other areas in the Lahontan basin should not have shortages in 1991, if the runoff of the Truckee and Carson Rivers is at least 100 percent of normal. The runoff of the Humboldt River will need to be at least 120 percent of normal in 1991 in order to avoid shortages on the Humboldt Project.

LOWER COLORADO REGION

The Lower Colorado Region includes most of Arizona and portions of California, Nevada, Utah, and New Mexico. The region encompasses the portion of the Colorado River drainage basin below Lees Ferry, Arizona (near Page, Arizona).

Water Year 1990

Soil moisture measurements indicated predominantly moderate to severely dry conditions at the beginning of the 1990 water year for most of the region. Conditions improved and degraded, variously, as the water year progressed. Due to late season precipitation, conditions improved substantially in most of Arizona and southern Nevada by year's end, resulting in moist to very moist conditions. However, indices for northwestern Arizona and southern California still showed extreme drought conditions. Overall, soil moisture content was much improved in the region at the beginning of water year 1991 compared to conditions at the beginning of the previous water year.

Snowpack conditions in the river basins originating in Arizona and western New Mexico were well below normal throughout the snowpack accumulation season. Snowpack was less than 50 percent of normal in all of the basins by May 1, 1990.

Reservoir inflow to the region, as gaged by inflow to Lake Powell in the Upper Colorado Region, was less than 70 percent of normal early in the year and degraded to less than 50 percent of normal by the end of the water year.

Reservoir storage in the Lower Colorado Region, consisting of storage on the main stem Colorado River, remained at about 80 percent of capacity throughout the year. (Storage at year's end was about 3 percent of capacity less than it was at the beginning of the year.) Reservoir storage in this region is reported as a percent of capacity, rather than as a percent of average, because carryover storage is provided for many years. The average for a particular time of the year is not as meaningful as it is for a reservoir that provides carryover storage on an annual cycle.

The low runoff in 1990 continued the dry pattern that has been causing a drawdown in the Colorado River reservoirs. The below average flows of 1988, 1989, and 1990 have reduced the storage in Lake Mead by about 7 million acre-feet. Minimum deliveries of storage water must be maintained to meet obligations pursuant to the laws that govern administration of the Colorado River. Deliveries during 1990 required to meet these obligations were 9.1 million acre-feet.

Projected Conditions for 1991

Under the most probable water supply conditions for 1991, Lake Mead will not reach a storage level greater than that of 1990, due partly to the need to refill upper basin reservoirs and also due to the dry soil conditions in the upper basin. Lake Mead is projected to continue to drop through the fall and winter, reaching its seasonal low point in March 1991. Deliveries from Lake Mead in 1991 are projected to be 8.8 million acre-feet.

UPPER COLORADO REGION

The Upper Colorado Region includes most of Utah and New Mexico and portions of Nevada, Idaho, Wyoming, Colorado, and Texas. The region encompasses the Colorado River drainage above Lees Ferry, Arizona, the Rio Grande basin, and the closed-basin drainages flowing westward from the Wasatch Range in Utah.

Water Year 1990

Soil moisture content indicated mild to severe drought conditions at the beginning of the water year for most of the region, although extreme drought circumstances were indicated for parts of the region. As the water year progressed, the Colorado River and upper Rio Grande drainages degraded until most areas were in extreme drought conditions by the end of the water year. Due to late precipitation, the lower Rio Grande was moist to very moist by the end of the

year. Overall, soil moisture measurements indicate much worse conditions for the region at the beginning of water year 1991 than at the beginning of water year 1990, except for the lower Rio Grande.

Snowpack in the river basins originating in western Colorado and southwestern Wyoming was below normal to well below normal on February 1, 1990, with the worst conditions located in southwestern Colorado. By May 1, conditions in southwestern Colorado had improved and those in southern Wyoming had degraded, but, overall, conditions remained below normal to well below normal.

Accumulated inflow to the region's reservoirs in the Colorado River basin was below normal to well below normal throughout the year. Total inflow to Lake Powell was less than 50 percent of normal. Also, accumulated inflow to Elephant Butte Reservoir on the Rio Grande was less than 50 percent of normal for the water year.

Reservoir storage was between 70 and 90 percent of capacity for reservoirs in the Colorado River and Rio Grande basins at the beginning of the water year. Storage conditions generally degraded for the region as the year progressed, with Lake Powell (the principal storage feature in the Colorado basin) dropping from 79 percent of capacity to 65 percent of capacity by year's end and Elephant Butte Reservoir on the Rio Grande dropping the same percentages through the year. As with the Lower Colorado Region, storage in this region is reported as a percent of capacity, rather than as a percent of average because carryover storage is provided by Lake Powell for many years at a time. The average for a particular time of the year is not as meaningful as it is for a reservoir that provides carryover storage on an annual cycle.

The runoff into Lake Powell during water year 1988 was approximately 70 percent of normal; in water year 1989, runoff was approximately 53 percent of normal; and in water year 1990, runoff was approximately 46 percent of normal. The low runoff years of 1988, 1989, and 1990 have caused a drawdown in each of the Colorado River system reservoirs. The vacant space on October 1, 1990, in the mainstem reservoirs, was about 16.7 million acre-feet. The vacant space has resulted from the three successive years of low inflow while maintaining the minimum deliveries of water out of storage facilities to meet obligations pursuant to "The Law of the River."

An abundance of mid-summer moisture in the Rio Grande Valley resulted in lower use of reservoir storage for the 1990 irrigation season than was predicted on March 1, 1990. Smaller projects generally used the predicted amount of reservoir storage, and they will need normal to above normal conditions to add water in storage in 1991. In general, conditions improved slightly over early forecasts as the season progressed.

Inflow to Elephant Butte Reservoir for 1990 for the March through July forecast period was 165,000 acre-feet, or 34 percent of normal. Inflow for water year 1990

was 351,000 acre-feet, or 40 percent of the long-term average. However, since combined storage at the end of 1989 was 1,706,000 acre-feet, or 201 percent of the long-term average, a full supply to all water users was available for the year.

The January 1, 1990, forecast for San Marcial Reservoir was 155,000 acre-feet, or 32 percent of normal. Each month thereafter, from February through May, the forecast was lower than 32 percent. The final forecast of June 1, 1990, ended at 34 percent. The forecast had very little impact on reservoir operations for 1990 because of the large amount of storage carried over from previous years.

Summer moisture also aided projects on the Pecos River; however, nearly all predicted use of reservoir storage was realized in 1990. Early predictions for streamflow runoff were very low (30-40 percent) throughout the basin. As the season progressed, late spring moisture increased the forecasts slightly, but heavy use of reservoir storage was anticipated. Beginning in early July, monsoonal type conditions in the basin developed and irrigation demand for reservoir storage decreased significantly. Good moisture conditions continued through September, resulting in good reservoir storage carryover potential for the 1991 season. Smaller Reclamation projects within the basin will require normal to above normal runoff to replenish reservoir storage used in the past 3 years.

Projected Conditions for 1991

In planning for 1991 Colorado River operations, three reservoir inflow scenarios were developed and analyzed. Statistically, inflows for these scenarios are approximately the upper quartile (equalled or exceeded 25 percent of the time), lower quartile (equalled or exceeded 75 percent of the time), and lower decile (equalled or exceeded 90 percent of the time). They have been respectively labeled the probable maximum, most probable, and probable minimum inflows.

The inflow volumes resulting from these assumptions were used as input data in Reclamation's monthly reservoir operation planning computer model, which is used to plan reservoir operations for the upcoming 12-month period. With the three levels of assumed water year 1991 inflow and reservoir storage conditions, studies showed that no project shortages would occur under any inflow scenario.

For the Rio Grand Project, projections for 1991 project operations were made for each of three water supply scenarios: the most probable (100 percent of normal), the reasonable minimum (25 percent of normal), and the reasonable maximum (200 percent of normal).

With the most probable runoff, a full supply of water would be available to most users along the lower Rio Grande. Further, this condition would result in a near full supply for the larger projects on the upper Rio Grande. Smaller projects in the upper Rio Grande would experience minor shortages.

With the reasonable minimum runoff, a full supply of water would be available to all users along the lower Rio Grande; however, there would be a serious shortage in 1992. With careful management of existing storage, larger projects like the Middle Rio Grande will get through the season. Extreme surface flow shortages would develop on the Pecos River, as carryover storage is essentially nonexistent at the present. This would result in farmers relying heavily on ground-water sources.

The reasonable maximum runoff would result in a full supply to all users on the lower Rio Grande. All projects within the upper Rio Grande basin would have full supplies, although the Middle Rio Grande Project would require supplemental releases in the late season. Conditions within the Pecos River basin under this scenario would provide a full water supply to Carlsbad Irrigation District, with some carryover storage potential.

GREAT PLAINS REGION

The Great Plains Region is Reclamation's largest region. It includes all of the States of North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma. In addition, it includes most of Montana, Wyoming, and Texas and about half of Colorado. It encompasses the Missouri River drainage and other tributaries to the Mississippi and Gulf Coast.

Water Year 1990

Soil moisture measurements varied widely at the beginning of the water year over this large region. On October 1, 1989, most of the region was in drought, ranging from mild to extreme drought circumstances. Exceptions were in northwestern Montana and southern Kansas and central Oklahoma, where moist conditions existed. As the year progressed into the spring and summer, additional moist areas were indicated, particularly in Kansas, Oklahoma, and northern Texas. However, by the end of the water year, very few areas with moist soil conditions remained. Overall, September 30, 1990, conditions in the region ranged from mild to extreme drought, with the extreme conditions concentrated mostly in the north. Some near-normal and moist conditions existed in Oklahoma and Texas at year's end. Overall, the soil moisture content indicated that conditions in the region at the beginning of water year 1991 on October 1, 1990, were similar to those at the beginning of the previous water year on October 1, 1989, but with some areal redistributions.

Snowpack on February 1, 1990, ranged from slightly below normal to near normal for the river basins originating in Montana, Wyoming, and Colorado. The range of conditions remained about the same near the end of the snow season on May 1, 1990, with some improvement in some basins in eastern Colorado.

Accumulated reservoir inflow ranged from above normal to below normal throughout the year. One of the more critical areas was the North Platte River basin originating in southeastern Wyoming. Two basins that were near normal were the Cheyenne River basin in Wyoming and South Dakota and the South Platte River basin in northeastern Colorado.

Reservoir storage was generally near normal in the tributaries to the upper Missouri River at the beginning of the 1990 water year and below normal on the tributaries to the lower Missouri River. By year's end on September 30, 1990, conditions were generally similar to the first of the year throughout the region, except in the Cheyenne and North Platte Rivers drainages in Wyoming, South Dakota, and Nebraska where conditions had degraded to well below normal.

Project water delivery shortages were experienced during water year 1990 in the Beaverhead River basin in Montana, the North Platte and Wind River basins in Wyoming, the James River basin in South Dakota, and several smaller Reclamation projects in Nebraska and Kansas. Because of the drought's impact on the Beaverhead River basin's (Clark Canyon Reservoir) water supply, the irrigation season was discontinued approximately 6 weeks earlier than normal.

Projected Conditions for 1991

Water deliveries for most projects in the Great Plains Region for 1991 should be adequate under most water supply scenarios, except for those projects that ended the year with low carryover storage. Expected conditions for two projects under dry conditions at the end of 1990 are discussed in the following paragraphs.

Bull Lake (Wind River Project) began the year with a content of 83,513 acre-feet (88 percent of normal). If 1991 inflows are near or above normal, Bull Lake would be expected to fill and have an adequate water supply for irrigation. However if lower decile inflows (equalled or exceeded 90 percent of the time) occur and a Wind River instream flow of 252 cubic feet per second is maintained, the reservoir will only fill to about 100,000 acre-feet, or about two-thirds full. If that occurs, the water supply would not be adequate to meet all irrigation needs, and the reservoir would be drafted to an unusually low level by the end of the year.

Based on September 30, 1990, storage, Clark Canyon Reservoir in the Beaverhead River basin would be expected to fill to the top of the joint-use pool only under high runoff conditions. Reservoir storage would be expected to fill to 155,000 acre-feet, or about 23,000 acre-feet below the top of the joint-use pool—during a normal runoff year. Storage under normal runoff conditions would be adequate to satisfy irrigation demands during the 1991 irrigation season. Under low runoff conditions, storage would be expected to fill to 130,000 acre-feet, or about 48,000 acre-feet below the top of the joint-use pool. Low runoff probably would result in shortage of irrigation water by the end of the 1991 irrigation season.

THE 1990 DROUGHT—AN ILLUSTRATED HISTORY

Portions of the West experienced a fourth year of drought in 1990. Low moisture conditions were evident based upon the indices, or measurement tools, used to assess drought. Although many indices demonstrate water supply conditions, each index measures a different factor.

Due to climate variables and water storage development in the Western United States, no single index can reflect all of the variables needed to measure drought. This chapter contains illustrations to demonstrate five different indices. Taken together, they show the growth or decline of drought in 1990, related to Bureau of Reclamation projects.

In the West, water storage in manmade reservoirs changes the natural water cycle. The amount of water that remains from one year to the next in those reservoirs may change the water supply picture. This carryover storage tends to mask the severity of drought until consecutive dry years lead to reservoir storage depletion. However, to assess the total water supply picture, the following indices are helpful: the Palmer Drought Severity Index, winter snowpack, streamflow forecasts, accumulated reservoir inflow, and reservoir storage supply. The remainder of this chapter illustrates these index measurements.

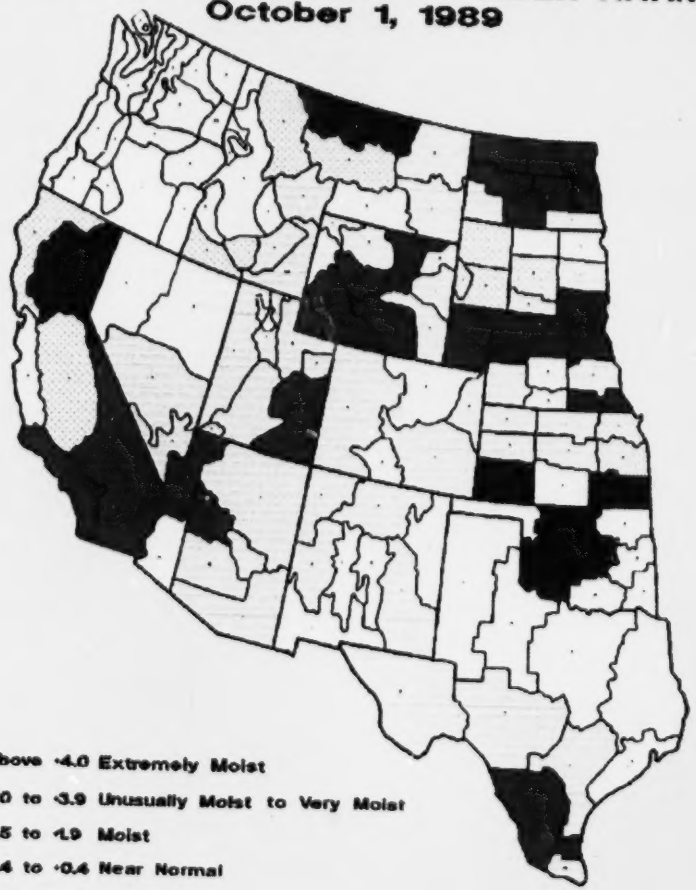
Palmer Drought Severity Index

The Palmer Drought Severity Index (PDSI) is a measurement tool for relative dryness or wetness, indicating prolonged and abnormal deficiencies or excesses of moisture. PDSI calculations are made from such indices as weekly precipitation totals, weekly average temperatures, moisture content of the soil, evapotranspiration rates, and previous indexes. The PDSI is based upon a scale of values, with values greater than +4 (wet) and less than -4 (dry) representing extreme conditions.

The PDSI is an important climatological tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. The index does not consider availability of snowmelt runoff, reservoir storage, or the availability of ground-water resources which can significantly influence an evaluation of water supply projections for a given area. The value of the PDSI is that it can provide important information about the following concerns: Will irrigated crops require more than the usual amount of water? Will precipitation run off into water channels or be absorbed into the soil? What is the degree of fire danger?

The PDSI maps on the following pages show soil moisture conditions at four intervals during 1990. As illustrated, soil moisture conditions in some sections of the West started dry and became even more arid as the season progressed. In particular, areas of California and the Colorado River Basin were extremely dry, causing increased water demand from storage for consumptive use.

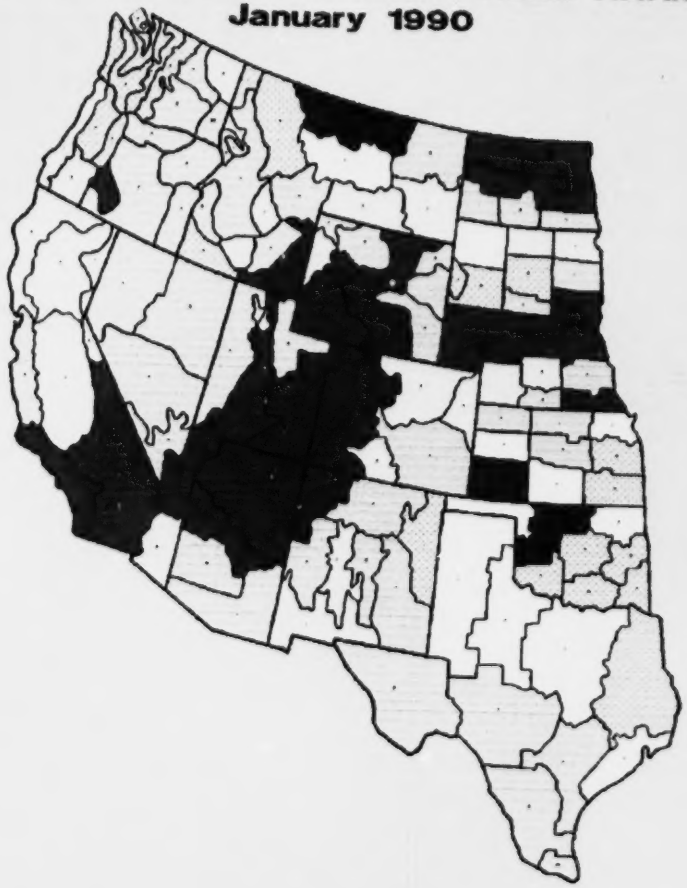
PALMER DROUGHT SEVERITY INDEX RATINGS
October 1, 1989



- Above +4.0 Extremely Moist
- +2.0 to +3.9 Unusually Moist to Very Moist
- +0.5 to +1.9 Moist
- -0.4 to +0.4 Near Normal
- -0.5 to -1.9 Mild Drought
- -2.0 to -3.9 Moderate to Severe Drought
- Below -4.0 Extreme Drought

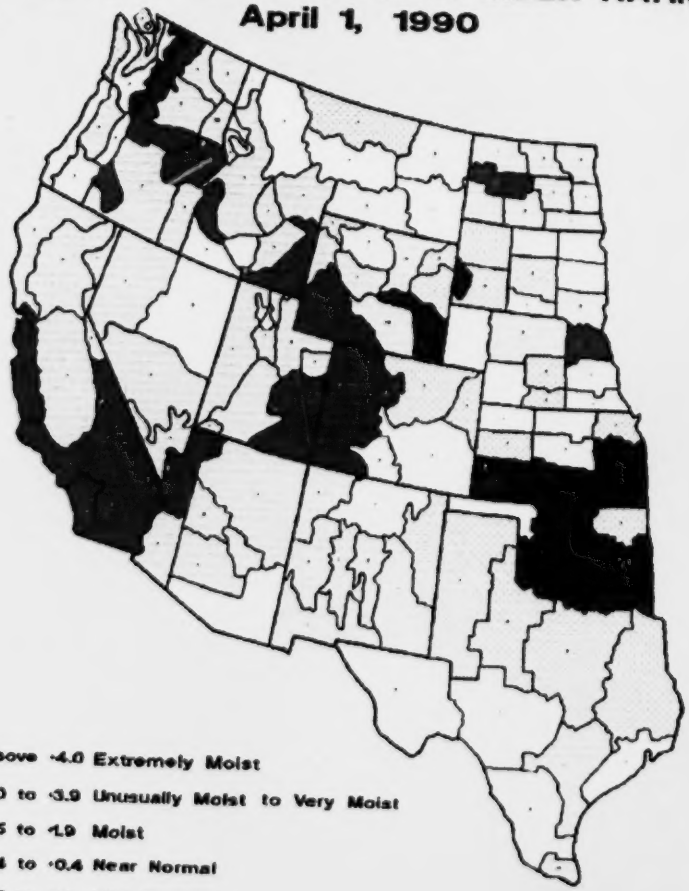
Data Provided by:
Climate Analysis Center
National Weather Service
Some Data are Preliminary

PALMER DROUGHT SEVERITY INDEX RATINGS
January 1990



Data Provided by:
Climate Analysis Center
National Weather Service
Some Data are Preliminary

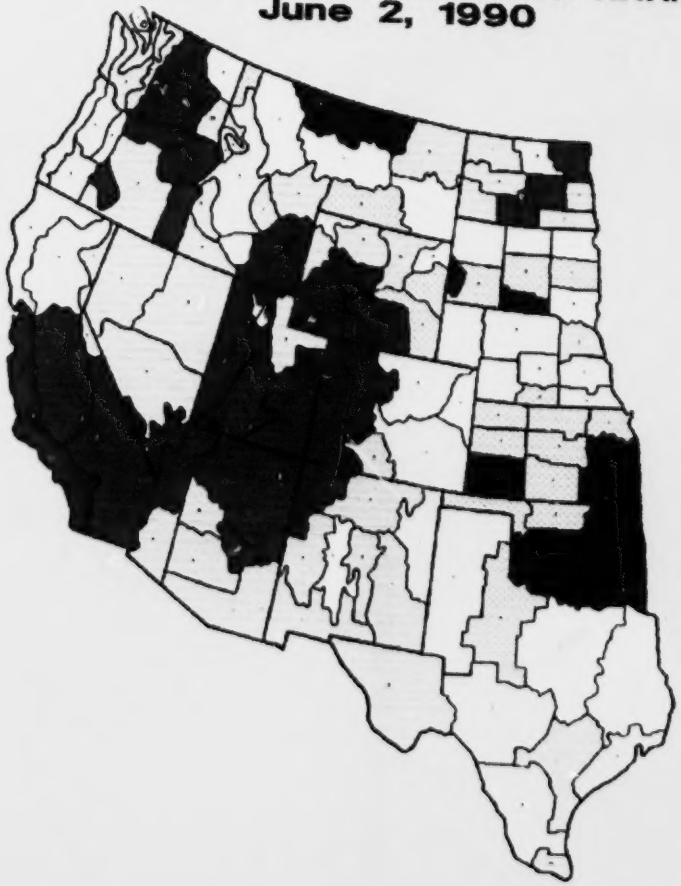
PALMER DROUGHT SEVERITY INDEX RATINGS
April 1, 1990



- Above +4.0 Extremely Moist
- +2.0 to +3.9 Unusually Moist to Very Moist
- +0.5 to +1.9 Moist
- -0.4 to +0.4 Near Normal
- -0.5 to -1.9 Mild Drought
- -2.0 to -3.9 Moderate to Severe Drought
- Below -4.0 Extreme Drought

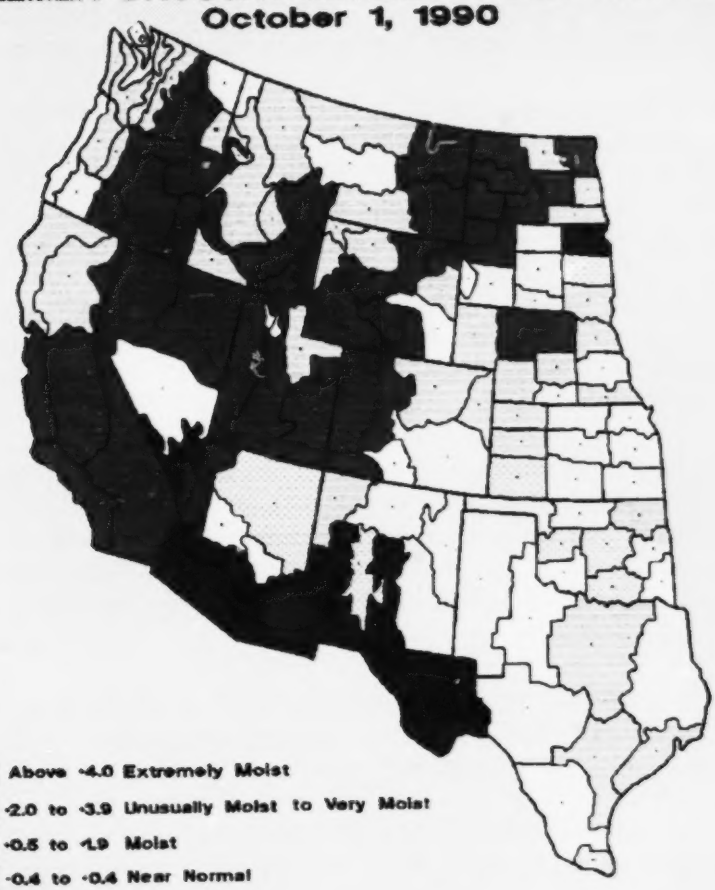
Data Provided by:
Climate Analysis Center
National Weather Service
Some Data are Preliminary

PALMER DROUGHT SEVERITY INDEX RATINGS
June 2, 1990



Data Provided by:
Climate Analysis Center
National Weather Service
Some Data are Preliminary

PALMER DROUGHT SEVERITY INDEX RATINGS
October 1, 1990



- Above +4.0 Extremely Moist
- +2.0 to +3.9 Unusually Moist to Very Moist
- +0.5 to +1.9 Moist
- -0.4 to +0.4 Near Normal
- -0.5 to -1.9 Mild Drought
- -2.0 to -3.9 Moderate to Severe Drought
- Below -4.0 Extreme Drought

Data Provided by:
Climate Analysis Center
National Weather Service
Some Data are Preliminary

Snow Water Equivalents

Most Reclamation projects rely on winter precipitation for project water supplies and replenishment of reservoir storage. The winter snowpack that accumulates at higher elevations is critical. Snowpack indicates the amount of water that will be captured in the lower elevation reservoirs, and, thus, available for storage and release during the dry summer season. Low snowpack conditions indicate low reservoir inflow; very high snowpack conditions, particularly when associated with high carryover storage, indicate the potential for spring floods. Reservoir operations—the water release schedule—must consider both the amount and timing of the spring snowmelt runoff.

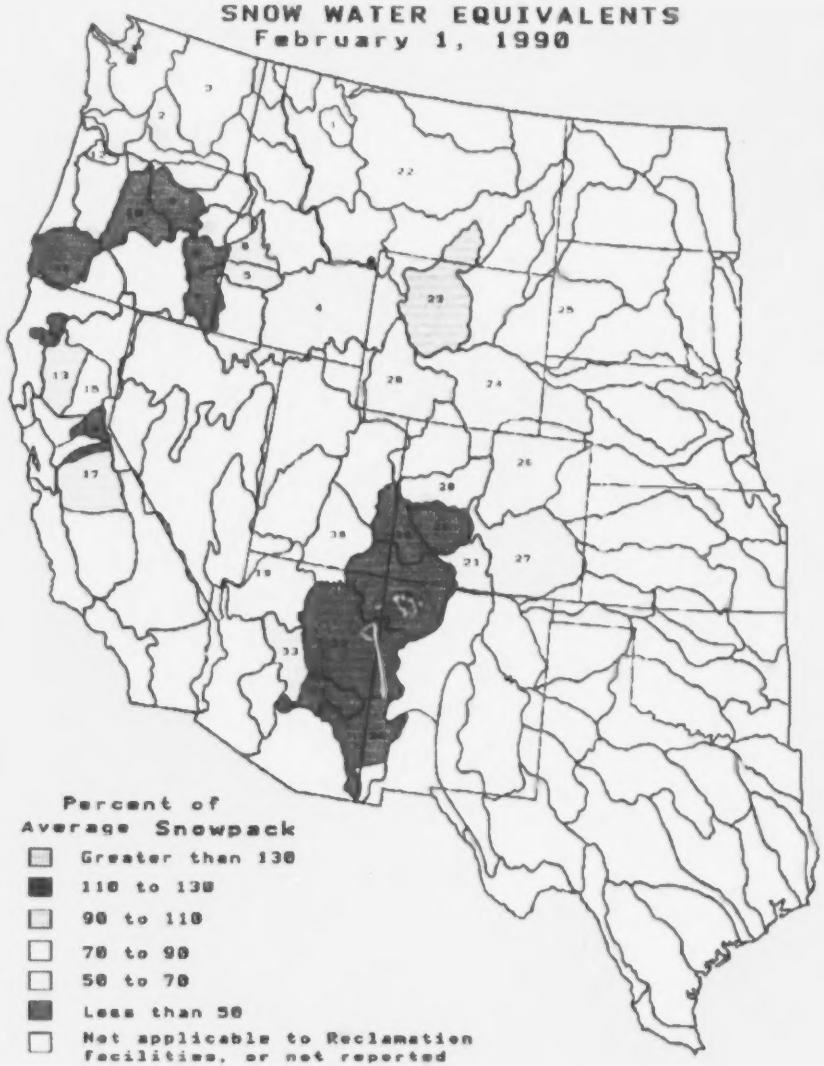
Snowpack can be thought of as "inches of water" temporarily stored in a frozen reserve. Two factors are considered: (1) the depth of the snow and (2) its moisture content. Deep snow may actually yield very little water if it is dry and powdery. Therefore, both factors are used to determine "snow water equivalents" which are an indication of the amount of reservoir inflow to be expected for the year.

Reservoir storage availability is largely based upon snowfall, and Reclamation begins its storage availability forecasts as early as possible each winter. Nevertheless, in many areas, a prediction of water supply for the following summer contains high levels of uncertainty until the winter storm season ends.

The following maps illustrate the snow water equivalents at two points during the winter of 1989-1990. Both maps summarize conditions as percentages of average. Numbers on the subbasins correspond to numbers on the following table, which provides a more detailed tabulation of the index measurement. Subbasins were chosen for illustration based upon availability of data and applicability to Reclamation projects.

In the West, most snow typically accumulates from January through April. Thus, the February 1, 1990, map shows the snowpack available near the beginning of the season, and the May 1, 1990, map shows the snow water equivalents near the end of the season. As shown, the percentages were extremely low in many areas. Particularly severe were areas of Oregon, California and Arizona. (Drought conditions in Arizona were relieved later in the season by a series of rain storms.)

SNOW WATER EQUIVALENTS
February 1, 1990



Percent of
Average Snowpack

- Greater than 130
- 110 to 130
- 90 to 110
- 70 to 90
- 50 to 70
- Less than 50
- Not applicable to Reclamation facilities, or not reported

NOTE: Selected River Basins

SNOW WATER EQUIVALENTS
May 1, 1990

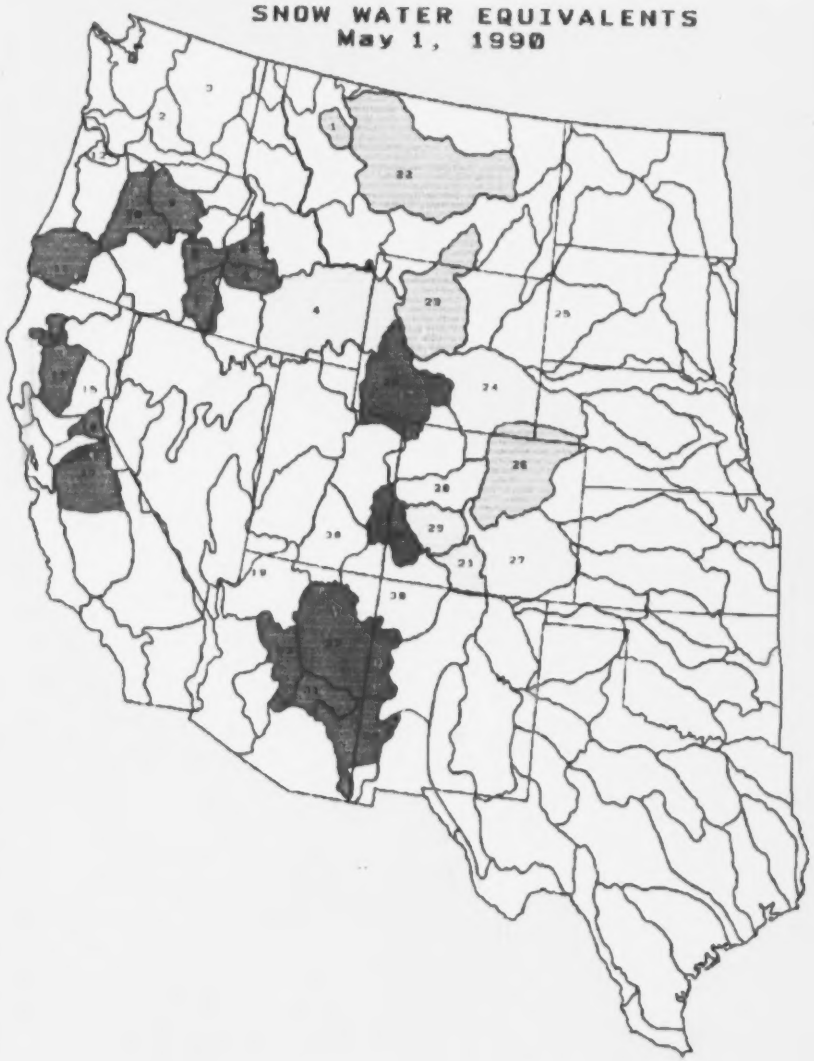


Table 1
SNOW WATER EQUIVALENTS[1]

River Basin Number	Basin	February 1, 1990	May 1, 1990
		----------percent of average---------	
1	South Fork Flathead	N/A	94
2	Yakima	83	76
4	Upper Snake	79	50
5	Boise[2]	55	40
6	Payette	55	40
7	Owyhee[3]	40	13
8	Malheur	40	13
9	Umatilla	17	9
10	Deschutes	17	40
11	Rogue[4]	13	13
13	Sacramento	54	28
14	Trinity	43	1
16	American	49	17
17	San Joaquin	61	23
18	Stanislaus	39	12
20	Colorado Headwaters	71	78
21	Upper Rio Grande	53	59
22	Upper Missouri	N/A[5]	96
23	Bighorn	100	109
24	North Platte	80	77
26	South Platte	80	100
27	Arkansas	62	79
28	Upper Green	87	49
29	Gunnison	44	68
30	San Juan[6]	23	76
31	Salt	17	0
32	Little Colorado	23	22
33	Verde	67	1
34	San Francisco-Gila	45	41
35	Dolores	23	76

[1] Equivalent depth of water contained in the snow. Basin numbers correspond to numbers on the map.

[2] Data for the Boise River basin are combined with Payette River basin data prior to averaging.

[3] Owyhee River basin data are combined with Malheur basin data prior to averaging.

[4] Rogue River basin data are combined with Umpqua River basin data prior to averaging.

[5] Not available.

[6] San Juan basin data is combined with Dolores River basin data prior to averaging.

Streamflow Forecasts

Streamflow forecast data are prepared by the Soil Conservation Service and the National Weather Service. Forecast data are compiled as of the first day of each month during the winter and spring months. Forecasts are important to reservoir operators because they provide another indicator of reservoir inflow to be used in determining how the spring runoff is likely to occur and how reservoirs should be operated.

The maps on the following pages show a summary of streamflow predictions that were available during the late winter and spring of 1990. It was apparent, based upon these forecasts, that much below average streamflow was likely over a large portion of the West.

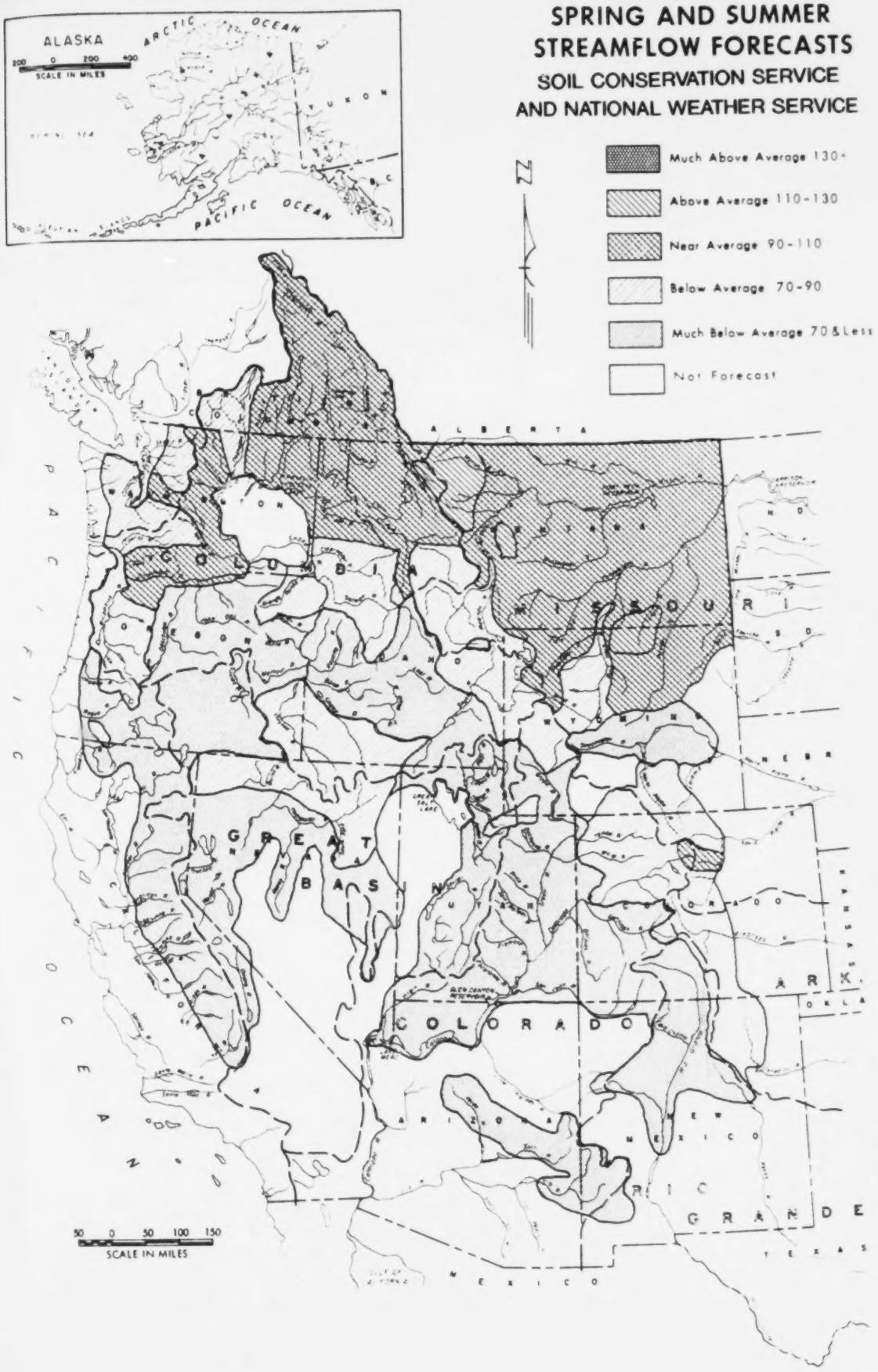
In February, streamflow forecasts showed less than 70 percent of average flows anticipated for the Colorado River Basin, the Sierra Nevada streams that feed reservoirs of the Central Valley Project in California, and the upper Snake River basin. Above average streamflow forecasts were largely limited to the upper Missouri River basin and portions of the Columbia River Basin.

As the season progressed, forecast conditions did not improve; in many areas, the predicted percentage of average flow became less and less. By April, it was clear that many reservoirs would not refill from the low levels of the end of the last season.

February 1, 1990

SPRING AND SUMMER STREAMFLOW FORECASTS

SOIL CONSERVATION SERVICE AND NATIONAL WEATHER SERVICE



MARCH 1, 1990

SPRING AND SUMMER STREAMFLOW FORECASTS

SOIL CONSERVATION SERVICE
AND NATIONAL WEATHER SERVICE

APRIL 1, 1990

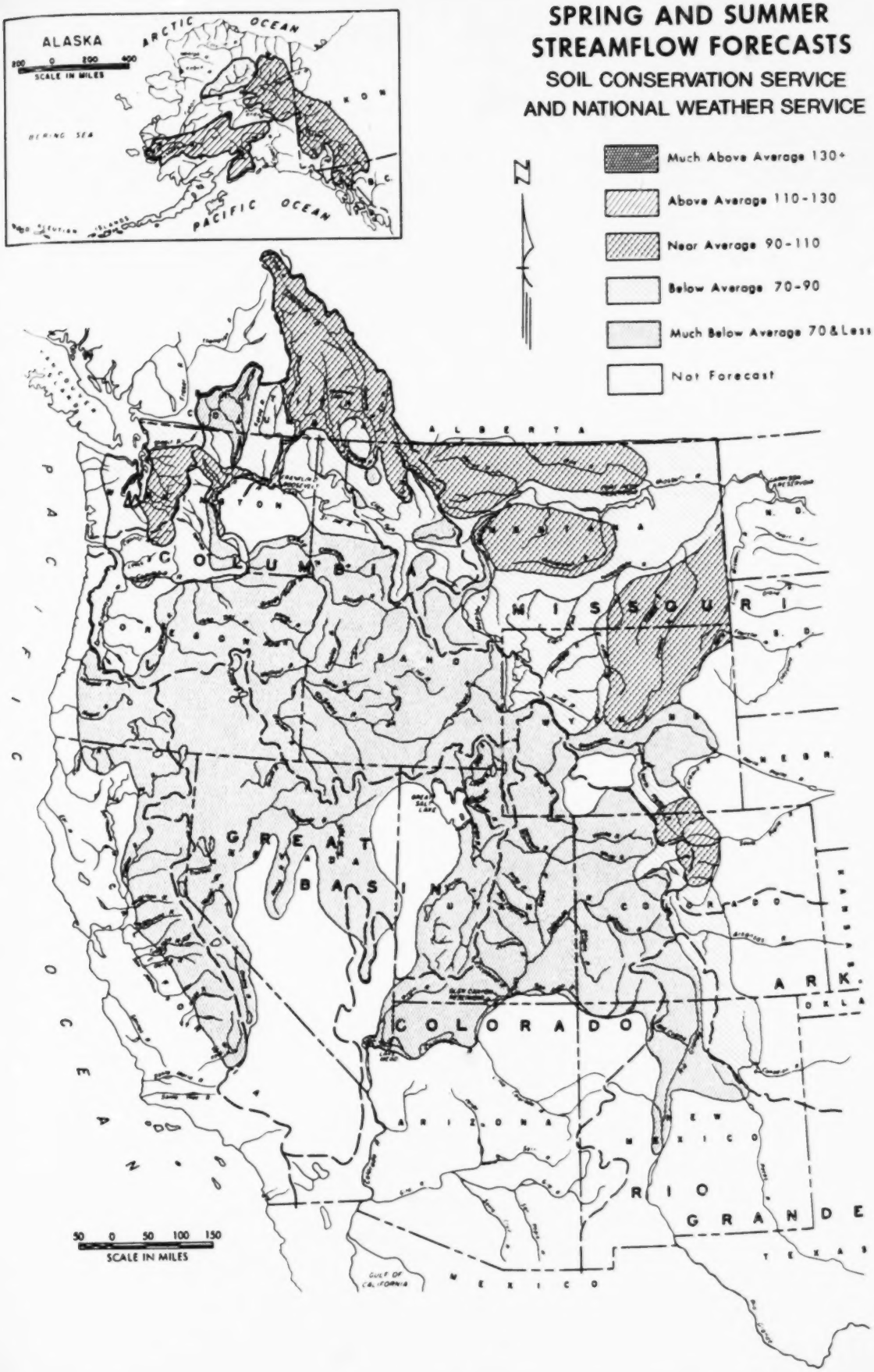
SPRING AND SUMMER STREAMFLOW FORECASTS

SOIL CONSERVATION SERVICE AND NATIONAL WEATHER SERVICE

May 1, 1990

SPRING AND SUMMER STREAMFLOW FORECASTS

SOIL CONSERVATION SERVICE AND NATIONAL WEATHER SERVICE

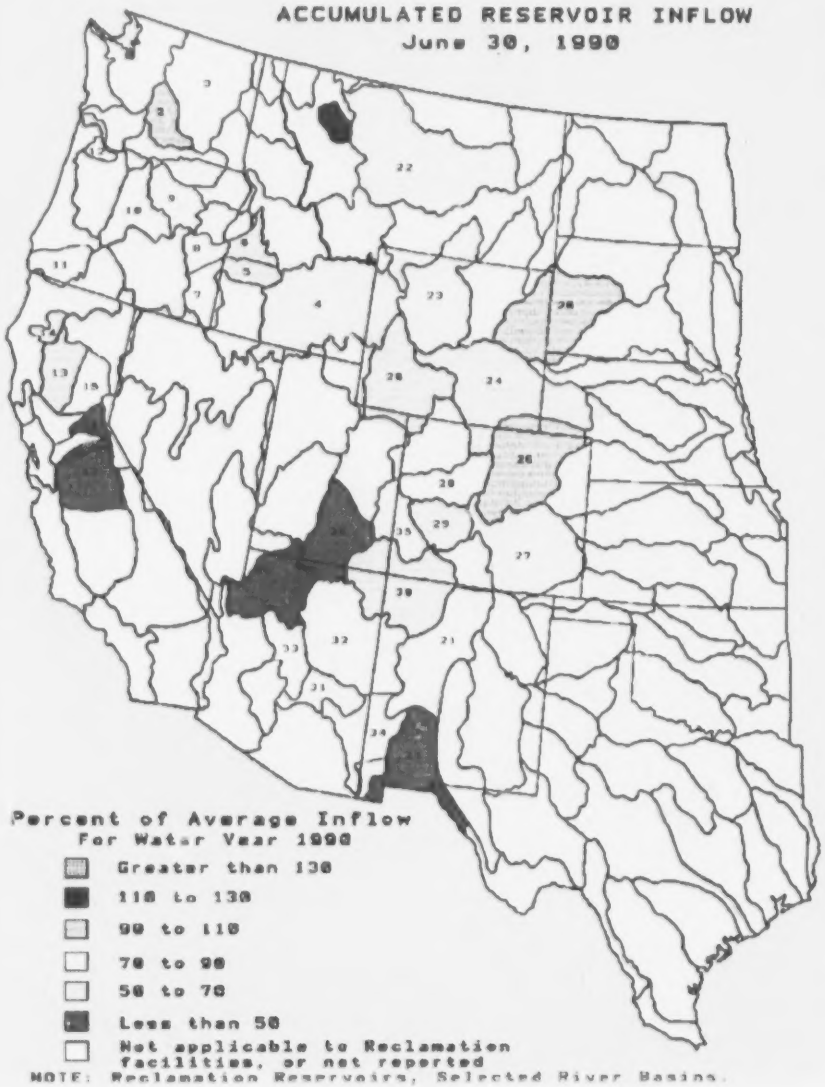


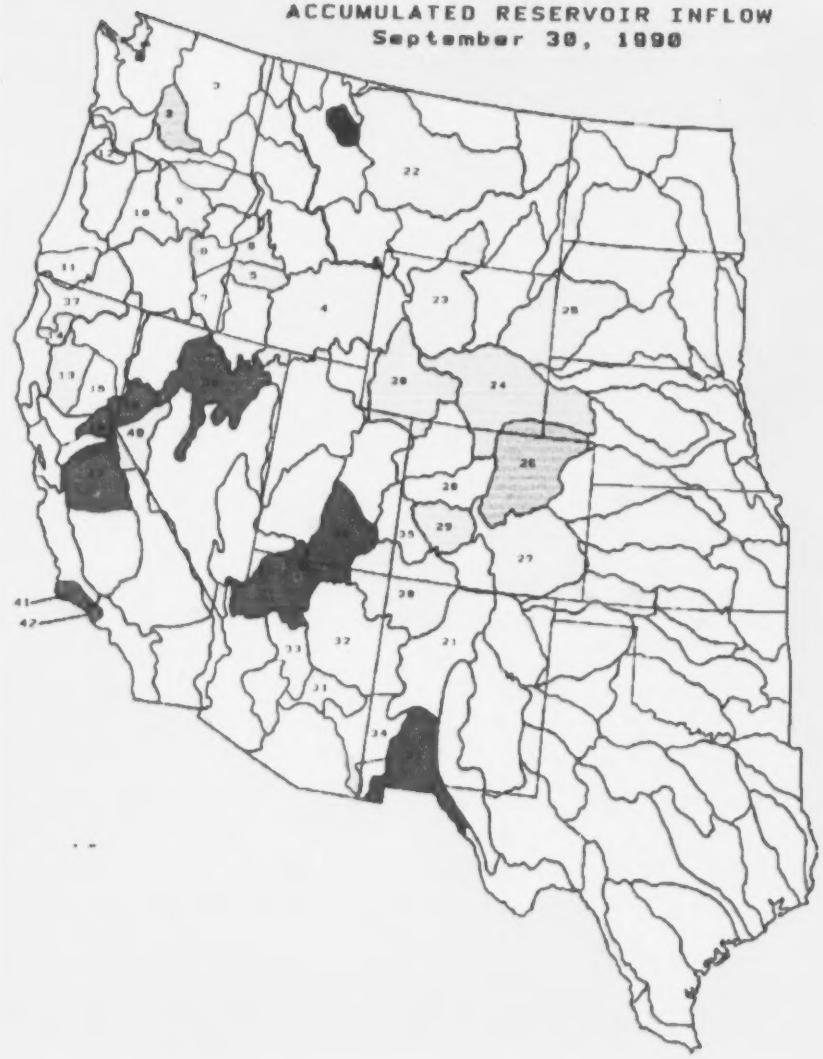
Accumulated Inflow

The accumulated inflow is the accumulated amount of water that has entered a reservoir to date. During the spring runoff season, much of this water is snowmelt. After the snowmelt runoff has subsided, inflow returns to base flow, which is maintained through natural streamflow from springs and other subsurface releases. Information about reservoir inflow allows reservoir operators to schedule reservoir releases to meet downstream requirements and, at the same time, hold back enough carryover storage for next year's needs.

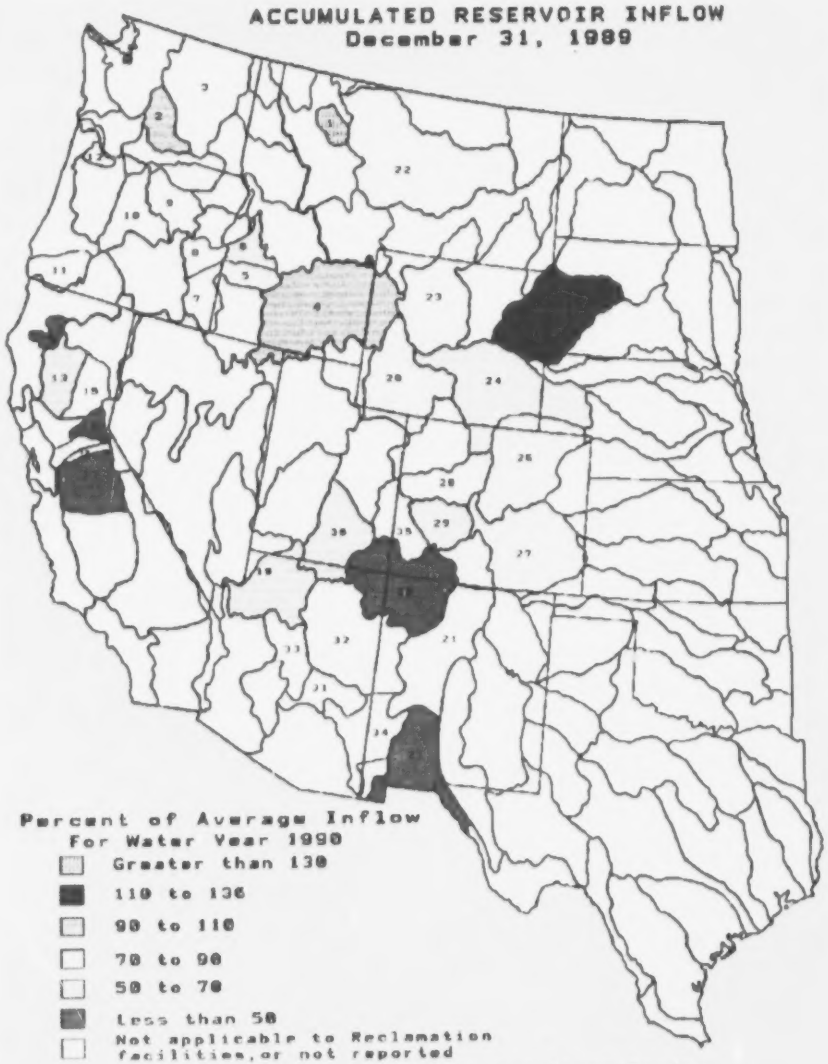
During drought, the amount of accumulated inflow to a reservoir is reduced and often requires a reduction in releases for downstream needs—a rationing of water. (Instantaneous inflow, the amount of water entering a reservoir at a particular point in time, is not the same as accumulated inflow. It is, nonetheless, an important measurement at some Reclamation reservoirs, where water deliveries in water-short years may be regulated by the instantaneous inflow on a particular date.)

During 1990, an early warming trend advanced the snowmelt; therefore, runoff peaked early and the accumulated inflow into many Reclamation reservoirs fell off earlier in the season than usual. By the end of June, reservoir inflow was severely below average in the Central Valley of California and in the Colorado River Basin.


ACCUMULATED RESERVOIR INFLOW
June 30, 1990
Percent of Average Inflow
For Water Year 1990
Greater than 130
110 to 130
90 to 110
70 to 90
50 to 70
Less than 50
Not applicable to Reclamation facilities, or not reported
NOTE: Reclamation Reservoirs, Selected River Basins.


ACCUMULATED RESERVOIR INFLOW
September 30, 1990

ACCUMULATED RESERVOIR INFLOW
December 31, 1989



Percent of Average Inflow
For Water Year 1990

- Greater than 130
- 110 to 130
- 90 to 110
- 70 to 90
- 50 to 70
- Less than 50
- Not applicable to Reclamation facilities, or not reported

NOTE: Reclamation Reservoirs, Selected River Basins.

ACCUMULATED RESERVOIR INFLOW
March 31, 1990

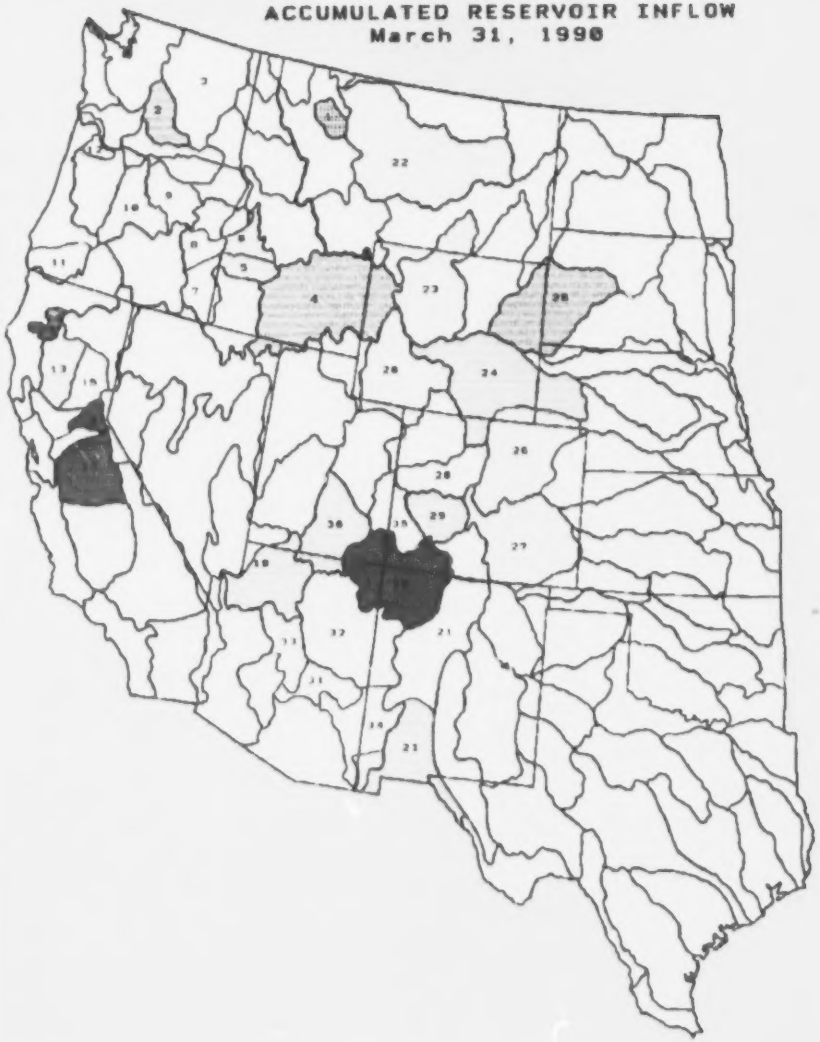


Table 2
BUREAU OF RECLAMATION ACCUMULATED RESERVOIR INFLOW
SELECTED RIVER BASINS[1]

River Basin Number	Basin	December 31, 1989 Inflow	December 31, 1989 Percent of Average	March 31, 1990 Inflow	March 31, 1990 Percent of Average	June 30, 1990 Inflow	June 30, 1990 Percent of Average	September 30, 1991 Inflow	September 30, 1991 Percent of Average
1	South Fork Flathead	664	317	951	221	2,912	128	3,343	126
2	Yakima	582	101	1,372	96	3,033	99	3,384	97
4	Upper Snake	620	92	1,124	92	3,044	75	3,769	70
5	Boise	140	71	329	62	1,039	56	1,189	55
6	Payette	185	66	433	67	1,372	63	1,547	62
13	Sacramento	754	58	1,931	52	3,021	59	3,616	62
14	Trinity	99	45	347	48	691	55	721	54
16	American	248	43	669	38	1,032	39	1,344	45
17	San Joaquin	109	46	261	38	524	36	767	41
18	Stanislaus	128	70	237	45	352	35	481	42
19	Lower Colorado[2]	893	69	1,733	68	4,390	48	5,477	46
21	Lower Rio Grande	57	46	169	62	268	35	350	39
22	Upper Missouri	688	82	1,261	82	2,321	74	2,747	71

[1] Inflow in 1,000 acre-feet. Basin numbers correspond to numbers on maps.

[2] Inflow into Lake Powell only

Table 2
BUREAU OF RECLAMATION ACCUMULATED RESERVOIR INFLOW
SELECTED RIVER BASINS[1]

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5	Boise	140	71	329	62	1,039	56	1,189	55
6	Payette	185	66	433	67	1,372	63	1,547	62
13	Sacramento	754	58	1,931	52	3,021	59	3,616	62
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[2] Inflow into Lake Powell only

BUREAU OF RECLAMATION ACCUMULATED RI[illegible]OIR INFLOW
SELECTED RIVER BASINS - Table 2 c[illegible]nued

River Basin Number	Basin	December 31, 1989 Inflow	December 31, 1989 Percent of Average	March 31, 1990 Inflow	March 31, 1990 Percent of Average	June 30, 1990 Inflow	June 30, 1990 Percent of Average	September 30, 1990 Inflow	September 30, 1990 Percent of Average
23	Bighorn	443	86	819	81	1,472	78	1,942	77
24	North Platte	16	57	139	69	488	56	1,052	56
25	Cheyenne	33	110	67	97	102	92	104	87
26	South Platte[1]	10	74	20	83	172	94	218	90
27	Arkansas[2]	63	78	120	81	299	71	427	80
28	Upper Green	106	80	233	83	677	55	930	56
29	Gunnison[3]	63	62	122	68	437	54	571	52
30	San Juan	42	49	86	46	439	65	612	71
36	Upper Colorado[4]	893	69	1,733	68	4,390	48	5,477	46
37	Klamath	N/A[5]	N/A	N/A	N/A	N/A	N/A	1,072	70
38	Humboldt	N/A	N/A	N/A	N/A	N/A	N/A	30	25
39	Truckee	N/A	N/A	N/A	N/A	N/A	N/A	129	27

[1] Includes Colorado River water inflow to Lake Granby which is the principal sources of supply for the Colorado-Big Thompson Project in the South Platte basin.

[2] Includes Fryingpan-Arkansas Project inflow.

[3] Inflow to Blue Mesa Reservoir

[4] Lake Powell inflow only.

[5] Not available

BUREAU OF RECLAMATION ACCUMULATED RESERVOIR INFLOW
SELECTED RIVER BASINS - Table 2 continued

River Basin Number	Basin	December 31, 1989 Inflow	December 31, 1989 Percent of Average	March 31, 1990 Inflow	March 31, 1990 Percent of Average	June 30, 1990 Inflow	June 30, 1990 Percent of Average	September 30, 1990 Inflow	September 30, 1990 Percent of Average
40	Carson	N/A	N/A	N/A	N/A	N/A	N/A	212	57
41	Santa Ynez	N/A	N/A	N/A	N/A	N/A	N/A	3	4
42	Ventura	N/A	N/A	N/A	N/A	N/A	N/A	-.3	-1

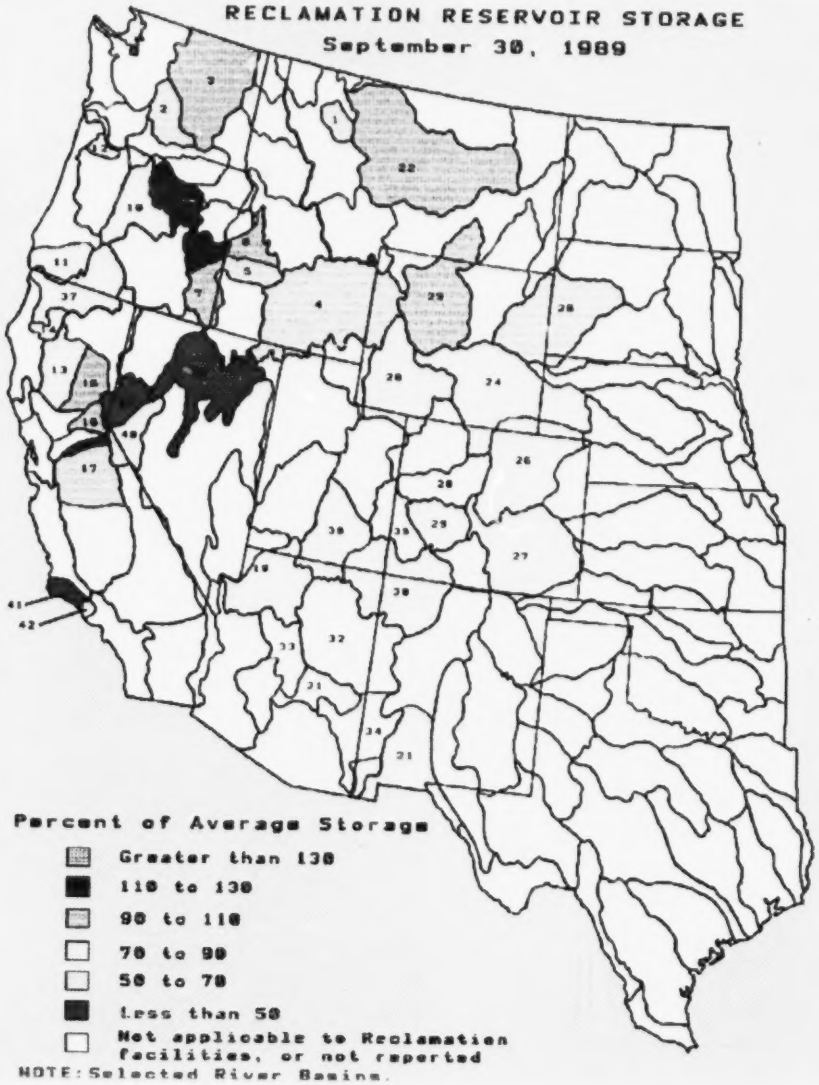
Reservoir Storage

Reservoir storage, for many projects, is the key to the adequacy of each year's water supply. The central task of Reclamation's reservoirs is to capture the spring runoff for release during the dry season. But, even under the best of conditions, a multitude of factors must be considered to balance reservoir storage with downstream water uses.

Many Reclamation reservoirs were authorized by the Congress to meet multiple water uses, and the requirements for each water use are balanced under the reservoir's operating plan. As pertinent, the operating plans answer the following questions: If carryover levels are high, how much will the reservoir need to be drawn down in the winter to capture possible spring floods? Will enough water be available to meet consumptive water requirements? How does the volume of water released from the reservoir compare to the volume of water flowing into it? If the winter snowpack is low, will there be enough water left in the reservoir pool at the end of the summer season to provide for next year's water requirements?

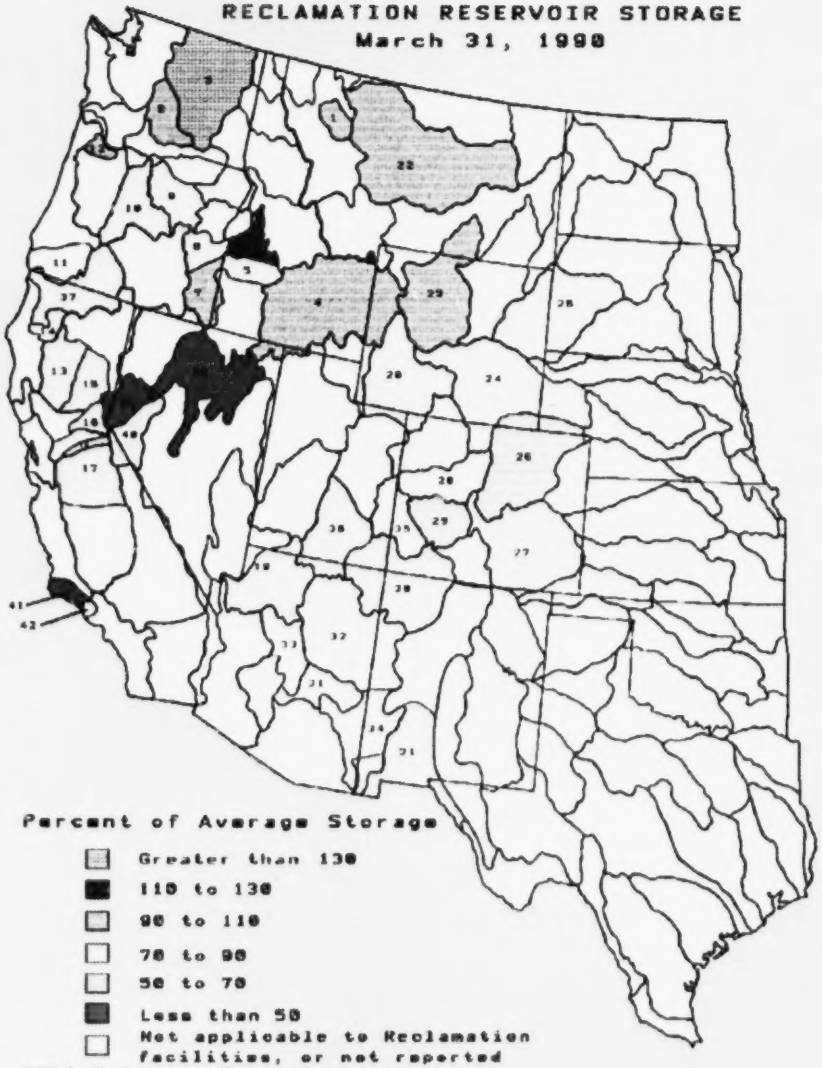
At the end of water year 1989, on September 30, 1989, Reclamation knew that carryover water supply in many reservoirs was dangerously low. However, the 1989-1990 winter precipitation was still uncertain. In the low storage areas, if winter precipitation was low, water supply would worsen; if precipitation was normal, water supply could be adequate; but, if precipitation was higher than normal, storage could be replenished while at the same time meeting water demands. The unknown factor--the amount of precipitation and hence the amount of reservoir inflow—would remain uncertain until well into the winter.

As the water year 1990 progressed, it became clear that water supplies would be inadequate to meet all water-user needs in some portions of the West. Of particular concern were areas of California, portions of the Colorado River basin, some subbasins in the upper Missouri River drainage, and in the central Snake River basin. The following maps trace the percent of normal reservoir storage as it appeared at the beginning of the water year, and at four more intervals until the end of the year on September 30, 1990.


RECLAMATION RESERVOIR STORAGE
September 30, 1989
Percent of Average Storage
Greater than 130
110 to 130
90 to 110
70 to 90
50 to 70
Less than 50
Not applicable to Reclamation facilities, or not reported
NOTE: Selected River Basins.

RECLAMATION RESERVOIR STORAGE
December 31, 1989

RECLAMATION RESERVOIR STORAGE
March 31, 1990



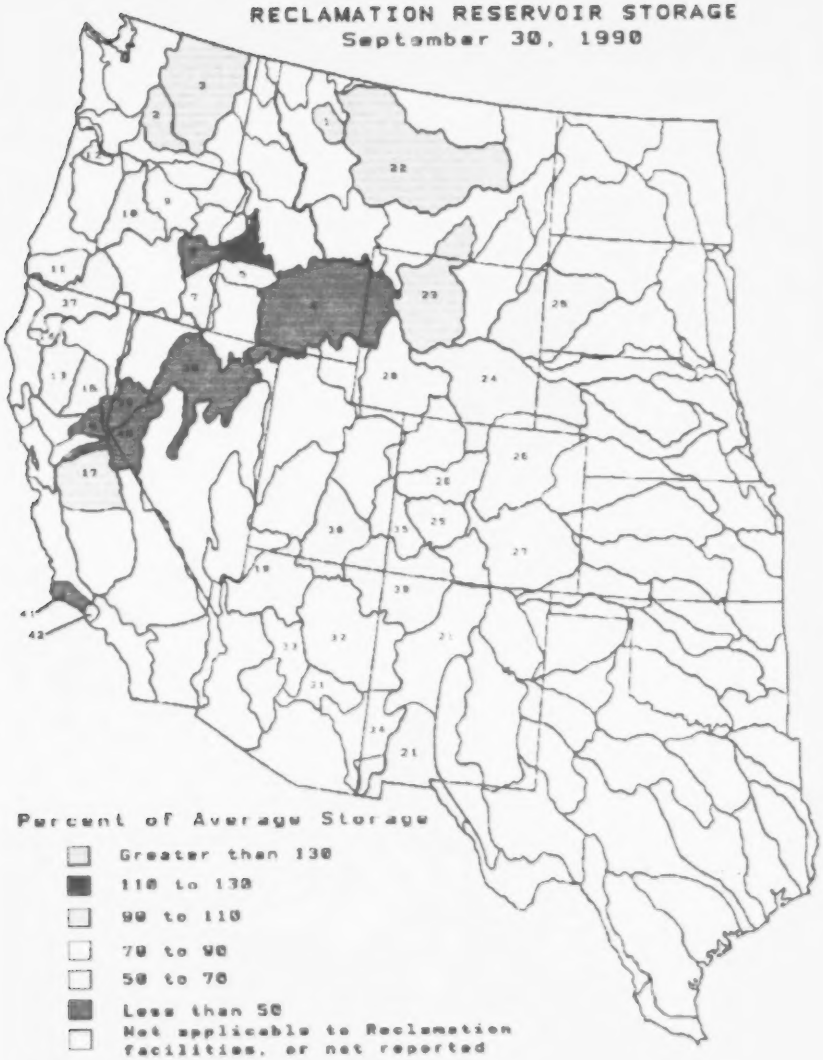
Percent of Average Storage

- Greater than 130
- 110 to 130
- 90 to 110
- 70 to 90
- 50 to 70
- Less than 50
- Not applicable to Reclamation facilities, or not reported

NOTE: Selected River Basins.

RECLAMATION RESERVOIR STORAGE
June 30, 1990

RECLAMATION RESERVOIR STORAGE
September 30, 1990



Percent of Average Storage

- Greater than 130
- 110 to 130
- 90 to 110
- 70 to 90
- 50 to 70
- Less than 50
- Not applicable to Reclamation facilities, or not reported

NOTE: Selected River Basins.

Table 3
BUREAU OF RECLAMATION RESERVOIR STORAGE
SELECTED RIVER BASINS[1]

River Basin Number	Basin	September 30, 1989 Storage	September 30, 1989 Percent of Average	December 31, 1989 Storage	December 31, 1989 Percent of Average	March 31, 1990 Storage	March 31, 1990 Percent of Average	June 30, 1990 Storage	June 30, 1990 Percent of Average	September 30, 1990 Storage	September 30, 1990 Percent of Average
1	South Fork Flathead	1,710	63	2,078	94	1,720	103	2,835	99	2,670	98
2	Yakima	228	57	442	79	717	96	1,061	106	401	101
3	Columbia	5,646	100	5,799	108	4,390	191	5,507	99	5,590	99
4	Upper Snake	1,422	68	2,277	85	3,352	108	3,019	83	791	38
5	Boise	362	69	453	69	609	84	761	75	301	58
6	Payette	468	103	487	110	543	130	811	104	539	118
7	Owyhee	403	98	423	94	589	96	457	73	209	51
8	Malheur	105	124	119	107	158	80	85	43	0	1
9	Umatilla	19	126	22	54	69	70	73	81	N/A[2]	N/A
10	Deschutes	206	84	298	88	411	89	314	77	136	55
11	Rogue	59	78	62	69	N/A	N/A	90	73	38	50
12	Tualatin	21	74	17	58	51	104	52	106	25	86
13	Sacramento	2,096	77	2,054	72	2,709	73	2,358	69	1,637	64

[1] Storage is expressed in thousands of acre-feet of water. One acre-foot is equivalent to about 326,000 gallons. The percentage of average storage refers to the average storage on that date over a historic period of record which varies by reservoir. Basin numbers correspond to numbers on the map.

[2] Not Available

BUREAU OF RECLAMATION RESERVOIR STORAGE
SELECTED RIVER BASINS - Table 3 continued

River Basin Number	Basin	September 30, 1989 Storage	September 30, 1989 Percent of Average	December 31, 1989 Storage	December 31, 1989 Percent of Average	March 31, 1990 Storage	March 31, 1990 Percent of Average	June 30, 1990 Storage	June 30, 1990 Percent of Average	September 30, 1990 Storage	September 30, 1990 Percent of Average
14	Trinity	1,376	76	1,257	73	1,431	73	1,628	74	1,162	67
15	Feather	2,150	91	1,889	77	2,092	73	1,693	58	1,163	53
16	American	571	96	312	61	503	73	525	67	178	33
17	San Joaquin	140	66	163	61	250	76	317	82	183	90
18	Stanislaus	672	46	763	55	769	50	568	36	378	28
19	Lower Colorado[1]	23,365	82	23,650	83	23,725	84	22,557	80	22,177	78
21	Lower Rio Grande	2,124	79	2,139	79	2,114	78	1,942	72	1,743	65
22	Upper Missouri	2,336	94	2,442	100	2,304	101	2,890	102	2,478	99
23	Bighorn	1,896	93	1,854	102	1,637	102	2,047	92	1,846	90
24	North Platte	1,038	72	1,115	74	1,251	77	1,470	74	914	65
25	Cheyenne	163	56	199	62	257	75	283	67	160	56
26	South Platte[2]	499	74	416	67	412	69	637	81	513	77
27	Arkansas[3]	361	88	356	78	393	75	456	87	385	83

[1] Percent of storage capacity, rather than percent of average.

[2] Includes Colorado River storage water for the Colorado Big-Thompson Project.

[3] Includes Fryingpan-Arkansas Project storage water

BUREAU OF RECLAMATION RESERVOIR STORAGE
SELECTED RIVER BASINS - Table 3 continued

River Basin		September 30, 1989		December 31, 1989		March 31, 1990		June 30, 1990		September 30, 1990	
Number	Basin	Storage	Percent of Average	Storage	Percent of Average	Storage	Percent of Average	Storage	Percent of Average	Storage	Percent of Average
28	Upper Green[1]	2,960	79	2,944	79	2,968	79	3,040	81	3,082	82
29	Gunnison[2]	585	71	563	68	576	69	680	82	618	75
30	San Juan[3]	1,310	77	1,231	73	1,179	70	1,367	81	1,361	80
36	Upper Colorado[4]	19,805	79	18,892	76	17,920	72	17,853	71	16,252	65
37	Klamath	503	87	581	91	774	88	667	77	357	63
38	Humboldt	20	22	12	11	35	30	13	10	5	5
39	Truckee	216	39	154	27	181	34	229	34	85	17
40	Carson	74	75	110	67	185	83	142	63	26	26
41	Santa Ynez	66	45	60	43	58	37	43	29	34	26
42	Ventura	169	78	160	75	156	70	149	68	138	67

[1] Flaming Gorge Dam storage water. Percent of storage capacity rather than percent of average storage.

[2] Blue Mesa Dam storage water. Percentage represents storage capacity rather than average storage.

[3] Percent of storage capacity rather than percent of average storage.

[4] Lake Powell storage only. Percentage represents storage capacity rather than average storage.